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# ESTIMATE OF THE OCCURRENCE AND DISTRIBUTION OF TOXICANTS IN STREAMBED SEDIMENTS OF THE SUSQUEHANNA RIVER SYSTEM

SUSQUEHANNA RIVER BASIN COMMISSION

RESOURCE QUALITY MANAGEMENT & PROTECTION DIVISION

FEBRUARY 1989

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# ESTIMATE OF THE OCCURRENCE AND DISTRIBUTION OF TOXICANTS IN STREAMBED SEDIMENTS OF THE SUSQUEHANNA RIVER SYSTEM

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## ABSTRACT

Streambed sediment from 12 of 24 riverine sampling sites in the Susquehanna River basin showed some degree of contamination, either by detection of organic priority pollutants, high concentrations of metals or the presence of some toxicant as indicated by the Microtox bioassay.

There was little correlation between the chemical detection of priority pollutants and the toxic response by the Microtox bacteria to sediment extracts.

There appeared to be a major decrease in the content of organochlorine insecticides and PCB's in the bed sediments from 1974 to 1988.

# ESTIMATE OF THE OCCURRENCE AND DISTRIBUTION OF TOXICANTS IN STREAMBED SEDIMENTS OF THE SUSQUEHANNA RIVER SYSTEM

## INTRODUCTION

In order to determine the occurrence and distribution of toxic organic and inorganic pollutant compounds in the streambed sediments within the Susquehanna River system, the Susquehanna River Basin Commission (SRBC), in cooperation with the National Oceanographic and Atmospheric Administration (NOAA) collected, chemically analyzed and conducted bioassays of extracts from streambed sediments representing 24 sites throughout the basin.

The term "toxic compound" is ambiguous at best, therefore, this study of toxic compounds is confined to the EPA list of "Priority Pollutant Compounds" found in Appendix A of this report. However, because of the way the samples were handled during the collection activities, the group of 31 volatile organic priority pollutant compounds were not sought for identification. One additional organic compound not on the priority list is reported because it was identified and is on both the EPA Appendix IX and Superfund lists.

Acknowledgement

We are grateful to Pennsylvania Department of Environmental Resources, Bureau of Laboratories personnel Sam Harvey, Chief, Division of Organic Chemistry and Radiation Measurement and Vincent White, Chief, Division of Inorganic Chemistry and Biological Services for their critical review of this report.

Previous Studies

A USGS/SRBC bed sediment study (Hollowell, 1975) followed by two SUNY/SRBC bed sediment studies (McDuffie, et al, 1979) (McDuffie, et al, 1981) indicated that chlorinated hydrocarbon pollutants such as DDT and its derivatives and PCB's could be found in the streambed sediments throughout the Susquehanna River system. In fact, McDuffie (1981) stated that in general, higher concentrations of PCB's and the DDT group were found in 1979 than during an earlier 1976-78 survey. This generalization was also true for the heavy metal content of sediments.

## METHODS OF STUDY

Studies have shown that as the sediment grain size decreases, the associated concentrations of trace elements increase (Jenne and others, 1980; Horowitz and Elrick, 1988). Thus, to best ensure that each bed sediment sample contained a disproportionately large amount of fine material, samples were collected during the summer low streamflow period when all sites could be waded and sampled discriminantly. The samples therefore, should not be considered representative of their respective sites but rather as indicators that a pollutant source exists or existed upstream of the sampling site and that specific pollutants are available for transport to Chesapeake Bay.

Streambed sediments were collected at low streamflow during August and September 1988 at 24 locations within the Susquehanna

River basin. Sampling locations are found in Figure 1. Low velocity areas such as the downstream end of islands, back eddies, pools, etc. were sought as sampling sites.

Field Procedures

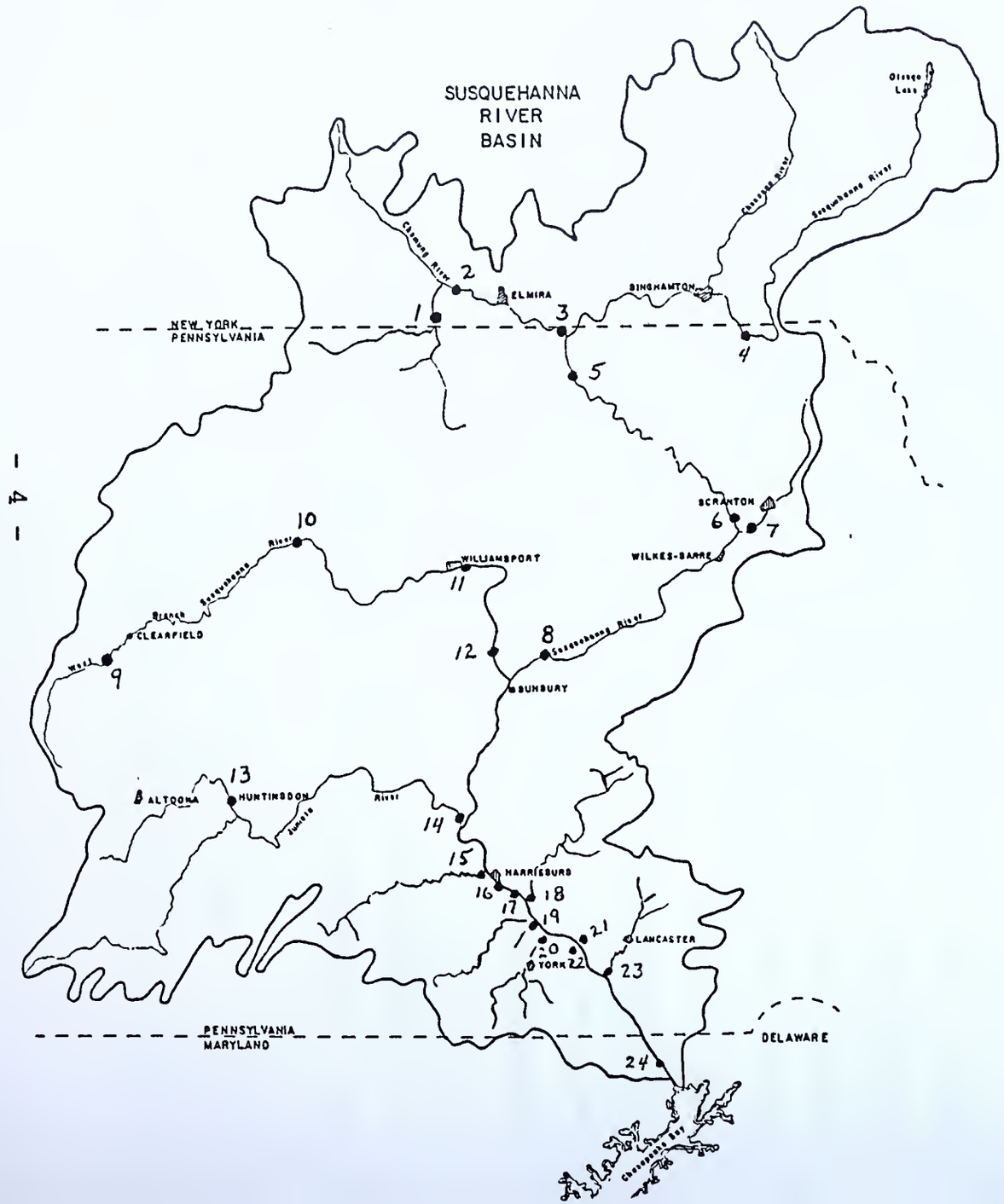
A special effort was made at each site to locate, by wading, areas where silt and clay size sediment would most likely be the predominant size fractions in the bed deposit. The sediments were hand scooped to a depth normally not greater than 3 cm using 500 ml teflon beakers and immediately sieved through 2 mm sieves to remove the coarse material.

Samples for organic analysis were sieved through a stainless steel 2 mm sieve and collected in a stainless steel bowl. This sieved sediment was thoroughly mixed with a teflon spoon and sub sampled into a fired glass jar for chemical analysis and into a plastic container for particle size analysis.

The samples collected for inorganic analysis were handled in the same manner except that the composition of the sieve and containers were polypropylene.

An additional sample for each site, comprised of a subsample from each of the samples for inorganic and organic chemical

FIGURE 1. SUSQUEHANNA RIVER BASIN SHOWING STREAMBED SEDIMENT SAMPLING SITES




| Site Number | Sampling Site |
|---|---|
| 1 | Tioga River @ Lindley, NY |
| 2 | Chemung River @ Corning, NY |
| 3 | Chemung River @ Athens, PA |
| 4 | Susquehanna River @ Hallstead, PA |
| 5 | Susquehanna River @ Ulster, PA |
| 6 | Susquehanna River Nr Falls, PA |
| 7 | Lackawanna River @ Duryea, PA |
| 8 | Susquehanna River @ Danville, PA |
| 9 | W. Branch Susquehanna River Nr Curwensville, PA |
| 10 | W. Branch Susquehanna River @ Renova, PA |
| 11 | W. Branch Susquehanna River @ Williamsport, PA |
| 12 | W. Branch Susquehanna River @ Milton, PA |
| 13 | Juniata River @ Huntingdon, PA |
| 14 | Juniata River Nr Amity Hall, PA |
| 15 | Conodoguinet Creek @ West Fairview, PA |
| 16 | Susquehanna River @ New Cumberland, PA |
| 17 | Susquehanna River @ Highspire, PA |
| 18 | Swatara Creek @ Middletown, PA |
| 19 | West Conewago Creek Nr York Haven, PA |
| 20 | Codorus Creek Nr Codorus Furnace, PA |
| 21 | Susquehanna River @ Columbia, PA |
| 22 | Susquehanna River @ Wrightsville, PA |
| 23 | Conestoga River @ Conestoga, PA |
| 24 | Susquehanna River Nr Port Deposit, MD |

analysis, was composited for use in the Microtox[1] bioassay.

All samples were immediately stored in an ice chest and later refrigerated until analysis.

## Laboratory Procedures

### Physical Characteristics

Particle size analysis of the streambed sediments were performed by the USGS Sediment Lab in Harrisburg, PA, on the wet sediment samples using a sieve-pipet method (Guy, 1969).

### Chemical Characteristics

Chemical extractions and their analysis were performed by the Pennsylvania Department of Environmental Resources (PaDER), Bureau of Laboratories.

#### Organic Constituents

The methods used to identify the priority pollutants (Appendix A) are based on procedures described in 40CFR136, "Guidelines Establishing Test Procedures for the Analyses of Pollutants Under the Clean Water Act." Analysis of the volatile organic compounds was not attempted. Minor procedural modifications for method 608 used for the identification of PCB's and organochlorine pesticides, and

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[1] The use of the brand name in this report is for identification purposes only and does not constitute endorsement by the Susquehanna River Basin Commission.

method 625 used for the identification of the semi volatile organics were incorporated to accommodate the sediment samples.

Inorganic Constituents

The constituents were extracted using method 3050 "Acid digestion of sediment, sludges and soils" found in EPA publication SW-846 entitled "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." Constituents in the extract were determined using atomic absorption instrumentation.

The bioassays were performed using the Microtox Analyzer (Beckman Instruments, 1982). The system is used in the same manner as other bioassay techniques recommended by the Environmental Protection Agency and the results are analogous to the Lethal Dose and Lethal Concentration values obtained in these tests. The Microtox system utilizes a species of bio-luminescent facultative bacteria, Photobacterium phosphoreum, that emit light which can be detected by the Microtox Analyzer. By measuring the light levels before and after the sample is introduced to the bacteria, a value is obtained that is expressed as the effective concentration (EC) in percent of the original test sample needed to cause a toxic response.

In order to obtain reliable estimates of toxicity, several dilutions of each test sample were prepared for analysis. A 2:1

serial dilution was used because it yields the most definitive test results for a wide range of potential toxicants. Before the dilutions were prepared, the salinity of the sample was adjusted with a 22% sodium chloride solution to prevent lysis of the bacteria when the sample was introduced. This yielded a solution containing 90% of the original test sample which was used to prepare the final dilutions. The 2:1 serial dilution was used to make solutions containing 90%, 45%, 22% and 11% of the original sample in addition to a non-toxic blank. The blank was used to determine the normal light loss of the bacteria during the time period of the test. In order to maintain reliability, duplicates of each serial dilution and the blank were prepared and tested simultaneously in the Microtox Analyzer.

The results are expressed as EC 50 values. The EC 50 correspond to the concentration in percent of the test sample causing 50% effect or reduction in the light output of the test organisms. Therefore, any value over 100% is considered to be non-toxic because the test sample would not be concentrated enough in its original form.

The bed sediment samples were subjected to an elutriation process after mixing four parts bed sediment and one part water by volume. The pH and dissolved oxygen concentration was measured for each sample prior to and after being subjected to continuous shaking for 24 hours because the redox conditions were not controlled. The supernatant from the settled mixture was

filtered through a 0.45 micron pore-size membrane filter for use in the Microtox bioassay.

## RESULTS

The sampling objective of collecting fine textured sediment appears to have been accomplished when comparing the mean of the textural classes between the 1974 and 1988 bed sediment samples.

| | Sand | Silt | Clay |
|---|---|---|---|
| 1974 | 76 | 15 | 9 |
| 1988 | 46 | 37 | 17 |

Data from Table 1 show the textural composition of the bed sediment and the identification of extracted organic priority compounds. Organic contaminants were detected in six of 24 sites with three of these sites identified as containing priority pollutants.

A total of four (4) organic priority pollutant compounds were identified at three sites and their content estimated in micrograms ($\mu$g) per kilogram (kg) wet sediment. They were: Chemung River at Athens, PA; pyrene - 100, fluoranthene - 100, chrysene - 100; Susquehanna River at Highspire, PA; aroclor 1260 - 240; Codorus Creek near Codorus Furnace , PA; pyrene - 1000 to 5000.

TABLE 1. PHYSICAL AND ORGANIC CHEMICAL ANALYSIS OF STREAMBED SEDIMENT IN THE SUSQUEHANNA RIVER BASIN

| Sampling Site | Sand | Silt | Clay | Extractable Organic Priority Pollutant Compounds | | |
|---|---|---|---|---|---|---|
| | Percent | | | Base-Neutral | Acid | Pesticides & PCB's |
| 1 | 70 | 24 | 6 | Not Detected | Not Detected | Not Detected |
| 2 | 42 | 44 | 14 | Not Detected | Not Detected | Not Detected |
| 3 | 33 | 51 | 16 | Pyrene, Fluoranthene Chrysene | Not Detected | Not Detected |
| 4 | 64 | 32 | 4 | Not Detected | Not Detected | Not Detected |
| 5 | 8 | 54 | 38 | Not Detected | *Para-Cresol | Not Detected |
| 6 | 38 | 52 | 10 | Not Detected | Not Detected | Not Detected |
| 7 | 47 | 37 | 16 | Not Detected | Not Detected | Not Detected |
| 8 | 37 | 39 | 24 | Not Detected | Not Detected | Not Detected |
| 9 | 18 | 74 | 8 | Not Detected | Not Detected | Not Detected |
| 10 | 64 | 17 | 19 | Not Detected | Not Detected | Not Detected |
| 11 | 62 | 24 | 14 | Not Detected | Not Detected | Not Detected |
| 12 | 31 | 42 | 27 | Not Detected | Not Detected | Not Detected |
| 13 | 48 | 31 | 21 | Not Detected | *Para-Cresol | Not Detected |
| 14 | 34 | 38 | 28 | Not Detected | *Para-Cresol | Not Detected |
| 15 | 8 | 58 | 34 | Not Detected | Not Detected | Not Detected |
| 16 | 72 | 21 | 7 | Not Detected | Not Detected | Not Detected |
| 17 | 12 | 56 | 32 | Not Detected | Not Detected | Aroclor 1260 |
| 18 | 19 | 55 | 26 | Not Detected | Not Detected | Not Detected |
| 19 | 47 | 39 | 14 | Not Detected | Not Detected | Not Detected |
| 20 | 88 | 11 | 1 | Pyrene | Not Detected | Not Detected |
| 21 | 63 | 28 | 9 | Not Detected | Not Detected | Not Detected |
| 22 | 19 | 62 | 19 | Not Detected | Not Detected | Not Detected |
| 23 | 67 | 21 | 12 | Not Detected | Not Detected | Not Detected |
| 24 | 76 | 19 | 5 | Not Detected | Not Detected | Not Detected |

*Compound is on EPA APPENDIX IX, AND SUPERFUND CLP LIST

In addition, para-cresol listed as an Appendix IX and Superfund compound (constituent which has been shown as toxic, carcenogenic, mutagenic or teratogenic) was found at three additional sites; the Susquehanna River at Ulster, PA (1300 $\mu$g/kg); Juniata River at Huntingdon, PA (2000 $\mu$g/kg); and Juniata River at Amity Hall, PA (2000 $\mu$g/kg).

The organochlorine insecticides were not detected.

Data from Table 2 show the textural composition of the sediment associated with the inorganic priority pollutant analysis and the quantity of detected extractable metals. The lack of detection of six metals is probably due to the fact that a 1 gram wet weight sample was used for the acid extraction rather than a wet sample weight which would provide the equivalent of 5-10 grams of oven dry sediment (Skougstad, and other, 1979).

For the seven metals detected in the streambed sediment, the Lackawanna River at Duryea contained the highest concentration of arsenic (As), copper (Cu), and lead (Pb) while the West Branch Susquehanna River at Williamsport contained the highest concentration of nickel (Ni) and zinc (Zn). The West Branch Susquehanna River at Milton contained the highest concentration of chromium (Cr) and the Susquehanna River at Wrightsville contained the highest concentration of mercury (Hg). The bed sediments in the Susquehanna River near Port Deposit, MD, contained the lowest concentration for five of the seven metals.

TABLE 2. PHYSICAL AND INORGANIC CHEMICAL ANALYSES OF STREAMBED SEDIMENT IN THE SUSQUEHANNARIVER BASIN

| Sampling Site | Sand | Silt | Clay | Extractable Metals | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ag | As | Be | Cd | Cr | Cu | Hg | Ni | Pb | Sb | Se | Tl | Zn |
| | Percent | | | mg/kg (dry weight) | | | | | | | | | | | | |
| 1 | 72 | 22 | 6 | | 9.3 | | | 14 | 24 | <0.10 | 84 | 40 | | | | 279 |
| 2 | 46 | 40 | 14 | N | 9.5 | N | N | 18 | 23 | <0.10 | 43 | 54 | N | N | N | 122 |
| 3 | 42 | 41 | 16 | | 7.1 | | | 23 | 31 | <0.10 | 43 | 40 | | | | 144 |
| 4 | 64 | 34 | 2 | O | 6.3 | O | O | 22 | 21 | <0.10 | 24 | 34 | O | O | O | 74 |
| 5 | 5 | 52 | 43 | | 11 | | | 20 | 40 | <0.10 | 74 | 67 | | | | 181 |
| | | | | T | | T | T | | | | | | T | T | T | |
| 6 | 38 | 52 | 10 | | 9.2 | | | 27 | 27 | <0.10 | 45 | 55 | | | | 113 |
| 7 | 37 | 34 | 29 | | 26 | | | 21 | 124 | 0.18 | 94 | 188 | | | | 210 |
| 8 | 42 | 41 | 17 | | 16 | | | 25 | 119 | 0.24 | 113 | 94 | | | | 547 |
| 9 | 85 | 12 | 3 | | 4.6 | | | 21 | 21 | <0.10 | 89 | 42 | | | | 206 |
| 10 | 82 | 11 | 7 | D | 10 | D | D | 27 | 37 | <0.10 | 42 | 65 | D | D | D | 201 |
| 11 | 64 | 17 | 19 | E | 13 | E | E | 46 | 68 | 0.11 | 507 | 114 | E | E | E | 1020 |
| 12 | 56 | 33 | 11 | | 8.4 | | | 60 | 60 | <0.10 | 468 | 92 | | | | 918 |
| 13 | 58 | 32 | 9 | T | 11 | T | T | 42 | 58 | 0.18 | 66 | 91 | T | T | T | 230 |
| 14 | 32 | 38 | 30 | | 7.3 | | | 19 | 38 | <0.10 | 49 | 94 | | | | 215 |
| 15 | 8 | 58 | 34 | E | 9.6 | E | E | 43 | 53 | <0.10 | 63 | 106 | E | E | E | 157 |
| 16 | --- | --- | --- | C | 11 | C | C | <12 | 43 | 0.11 | 149 | 48 | C | C | C | 350 |
| 17 | 13 | 57 | 30 | | 16 | | | 38 | 82 | 0.22 | 113 | 100 | | | | 439 |
| 18 | 36 | 46 | 18 | T | 12 | T | T | 30 | 79 | 0.11 | 63 | 116 | T | T | T | 394 |
| 19 | 16 | 54 | 30 | | 9.6 | | | 31 | 35 | <0.10 | 33 | 80 | | | | 111 |
| 20 | 65 | 32 | 3 | E | 2.9 | E | E | 15 | 33 | 0.14 | 34 | 69 | E | E | E | 134 |
| 21 | 65 | 26 | 9 | D | 5.3 | D | D | 17 | 32 | <0.10 | 48 | 81 | D | D | D | 118 |
| 22 | 32 | 58 | 10 | | 9.0 | | | 29 | 49 | 0.29 | 42 | 134 | | | | 232 |
| 23 | 71 | 18 | 11 | | 11 | | | 23 | 70 | 0.18 | 70 | 78 | | | | 258 |
| 24 | 83 | 13 | 4 | | 3.1 | | | 16 | 13 | <0.10 | 23 | 28 | | | | 45 |

Data in Table 3 shows the dissolved oxygen and pH values measured during the bed sediment elutriation process. The data show that the low dissolved oxygen concentrations, did not hinder the activity of the facultative anaerobic bacteria used in the bioassay. The pH values were near neutral for all samples except for the forest soil. Three soils were used for comparison purposes. Farm soil #1 was subjected to heavy annual applications of cow manure. Farm soil #2, while not manured, received liberal annual applications of commercial fertilizer. The third soil was a virgin forest soil. Table 4 shows the results of the Microtox bioassay. The EC 50 values for the 5, 15 and 30 minute assays are reported because different types of toxicant results in various responses from the bacteria. The data shows that the Microtox photobacteria responded to toxicant(s) in bed sediment samples from four of the 24 sites. The differences in response time are probably due to the type of toxicant present as explained in the Microtox operating manual. Phenol is an example of one type of toxicant that will cause an immediate response from the bacteria followed by a period of stabilization. Other chemicals may result in the most severe light loss between 10 and 25 minutes. Bivalent metals are indicative of toxicants that tend to accumulate in the tissues of the bacteria, therefore, causing higher toxicity levels as the exposure time increases. It is believed that the toxicity response shown by the forest soil extract was due to its naturally occurring low pH.

TABLE 3. DISSOLVED OXYGEN AND PH VALUES OF BED SEDIMENT EXTRACTS FOR MICROTOX BIOASSAY

| Sampling Site | Dissolved Oxygen | | pH | |
|---|---|---|---|---|
| | Before Shaking | After Shaking for 24 Hrs | Before Shaking | After Shaking for 24 Hrs |
| 1 | 0.23 | 0.59 | 7.7 | 7.4 |
| 2 | 0.18 | 0.21 | 7.3 | 7.0 |
| 3 | 0.20 | 0.20 | 7.5 | 7.2 |
| 4 | 0.22 | 0.22 | 7.3 | 6.8 |
| 5 | 0.25 | 0.20 | 7.1 | 6.8 |
| 6 | 0.30 | 1.20 | 7.0 | 6.8 |
| 7 | 0.20 | 0.20 | 7.0 | 6.4 |
| 8 | 0.35 | 0.21 | 7.4 | 7.1 |
| 9 | 0.30 | 0.20 | 8.0 | 7.5 |
| 10 | 0.30 | 0.24 | 6.8 | 6.6 |
| 11 | 0.60 | 1.60 | 6.9 | 6.0 |
| 12 | 0.28 | 0.30 | 8.4 | 8.0 |
| 13 | 0.30 | 0.18 | 7.2 | 7.0 |
| 14 | 0.30 | 0.25 | 7.2 | 6.9 |
| 15 | 0.35 | 0.20 | 7.2 | 6.9 |
| 16 | 0.35 | 0.30 | 7.6 | 7.2 |
| 17 | 0.30 | 0.22 | 7.5 | 6.8 |
| 18 | 0.30 | 0.20 | 7.4 | 7.0 |
| 19 | 0.35 | 0.20 | 7.1 | 6.6 |
| 20 | 0.35 | 0.20 | 7.3 | 6.8 |
| 21 | 0.30 | 0.20 | 7.5 | 7.1 |
| 22 | 0.40 | 0.17 | 7.6 | 7.0 |
| 23 | 0.35 | 0.21 | 7.5 | 7.0 |
| 24 | 0.88 | 0.55 | 7.9 | 6.8 |
| Farm Soil #1 | 9.2 | 8.6* | 6.1 | 6.1* |
| Farm Soil #2 | 9.4 | 8.4* | 7.3 | 7.2* |
| Forest Soil | 10.2 | 8.1* | 5.0 | 5.0* |

* Values Determined After 5 Days

TABLE 4. RESULTS OF MICROTOX BIOASSAY

| Sampling Site | Percent of Sample Required to Cause 50% Reduction in Light Output EC 50 | | | |
|---|---|---|---|---|
| | Non-Toxic | 5 min | 15 min | 30 min |
| 1 | X | --- | --- | --- |
| 2 | X | --- | --- | --- |
| 3 | X | --- | --- | --- |
| 4 | X | --- | --- | --- |
| 5 | X | --- | --- | --- |
| 6 | X | --- | --- | --- |
| 7 | X | --- | --- | --- |
| 8 | --- | --- | 87 | 89 |
| 9 | X | --- | --- | --- |
| 10 | --- | --- | --- | 70 |
| 11 | X | --- | --- | --- |
| 12 | X | --- | --- | --- |
| 13 | X | --- | --- | --- |
| 14 | --- | --- | 77 | --- |
| 15 | X | --- | --- | --- |
| 16 | --- | --- | --- | --- |
| 17 | X | --- | --- | --- |
| 18 | X | --- | --- | --- |
| 19 | X | --- | --- | --- |
| 20 | --- | 67 | --- | 82 |
| 21 | X | --- | --- | --- |
| 22 | X | --- | --- | --- |
| 23 | X | --- | --- | --- |
| 24 | X | --- | --- | --- |
| Farm Soil #1 | X | --- | --- | --- |
| Farm Soil #2 | X | --- | --- | --- |
| Forest Soil | --- | --- | 94 | --- |

Table 5 shows the location of all sampling sites, sites where organic pollutants were detected, the location of the highest concentrations of priority metals, and sampling sites where the Microtox bioassay indicated a toxic response. With the exception of two sites, there is no correlation between the detection of the priority chemical pollutants and the toxic response by the photobacteria. This means that although chemical priority pollutants may be associated with the sediment, conditions other than those imposed by this study are required for their dissociation and subsequent toxic effect on the test organism or that toxics other than theh priority pollutants were present in the sediment.

Table 6 is a compilation of the sampling sites and the concentration of organochlorine insecticides and PCB's found in the 1974 SRBC/USGS bottom sediment survey. It should be noted that the insecticides were found in fifteen of the nineteen sampled sites. In contrast, the 1988 survey did not detect a single organochlorine insecticide. It should also be noted that in 1974 PCB's were detected in fourteen of the nineteen sampled sites while in 1988 was found at only one site. This comparison implies that the content of organochlorine insecticides and PCB's has decreased throughout the Susquehanna River Basin.

The concentration of extractable metals in the 1988 bed sediment samples were normally higher than the concentrations found in the 1974 samples. This is most likely due to the fact

TABLE 5. TABULATION OF POLLUTANT DETECTION AND BIOASSAY RESPONSE

| Sampling Site | Chemical Analysis | | Microtox Indicator Response |
|---|---|---|---|
| | Pollutant | | EC 50 |
| | Organic | Inorganic | |
| 1 | --- | --- | - |
| 2 | --- | --- | - |
| 3 | X | --- | - |
| 4 | --- | --- | - |
| 5 | X | --- | - |
| 6 | --- | --- | - |
| 7 | --- | X | - |
| 8 | --- | --- | + |
| 9 | --- | --- | - |
| 10 | --- | --- | + |
| 11 | --- | X | - |
| 12 | --- | X | - |
| 13 | X | --- | - |
| 14 | X | --- | + |
| 15 | --- | --- | - |
| 16 | --- | --- | - |
| 17 | X | --- | - |
| 18 | --- | --- | - |
| 19 | --- | --- | - |
| 20 | X | --- | + |
| 21 | --- | --- | - |
| 22 | --- | X | - |
| 23 | --- | --- | - |
| 24 | --- | --- | - |
| Farm Soil #1 | --- | --- | - |
| Farm Soil #2 | --- | --- | - |
| Forest Soil | --- | --- | + |

X Detected
+ Toxicity Indicated
- No Response

TABLE 6. PESTICIDE RESIDUE -- 1974

| Sampling Site | Aldrin | Chlordane | DDD | DDE | DDT | Dieldrin | Endrin | Heptachlor Epoxide | Heptachlor | Lindane | PCB | PCN | Toxephene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mg/kg (dry weight) | | | | | | | | | | | | |
| Tioga River @ Lindley, NY | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemung River @ Corning, NY | | | | | | | | | | | | | |
| **Chemung River @ Athens, PA | | | | | | | | | | | | | |
| Susquehenne River @ Hallstead, PA | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 6 | --- | --- |
| Susquehanna River @ Ulster, PA | --- | --- | * | --- | --- | 1.2 | --- | --- | --- | --- | 16 | --- | --- |
| **Susquehanna River Nr Falls, PA | | | | | | | | | | | | | |
| Leckawanna River @ Duryea, PA | --- | --- | 5.2 | --- | --- | 13 | 0.8 | --- | --- | --- | 150 | --- | --- |
| Susquehanna River @ Danville, PA | --- | 6 | 1.9 | 1.0 | 6.9 | 1.8 | --- | --- | --- | --- | 42 | --- | --- |
| **W. Branch SusquehannaRiver Nr Curwensville, PA | | | | | | | | | | | | | |
| W. Branch Susquehanna River @ Renova, PA | --- | --- | 0.4 | 0.4 | 0.5 | --- | --- | --- | --- | --- | --- | --- | --- |
| W. Branch Susquehenna River @ Williamsport, PA | --- | 8 | 2.2 | 2.3 | 3.0 | 2.9 | --- | --- | --- | --- | 12 | --- | --- |
| W. Brench Susquehanna River @ Hilton, PA | --- | 19 | 7.9 | 2.6 | 12 | 17 | --- | --- | --- | --- | 62 | --- | --- |
| **Junieta River @ Huntingdon, PA | | | | | | | | | | | | | |
| Junieta River Nr Amity Hall, PA | --- | 23 | 5.2 | --- | 6.7 | 2.9 | 1.5 | 0.8 | --- | --- | 66 | --- | --- |
| Conodoguinet Creek @ West Fairview, PA | --- | --- | 0.3 | 0.2 | --- | 0.1 | --- | --- | --- | --- | --- | --- | --- |
| Susquehanna River @ New Cumberland, PA | --- | 10 | 2.4 | 2.0 | 2.4 | 1.8 | 0.2 | 0.1 | --- | --- | 25 | --- | --- |
| Susquehanna River @ Highspire, PA | --- | 60 | 11 | 4.0 | 5.3 | 5.2 | --- | --- | --- | --- | 700 | --- | --- |
| Swatera Creek @ Middletown, PA | --- | --- | 0.7 | 0.4 | 1.1 | 0.1 | --- | --- | --- | --- | --- | --- | --- |
| W. Conewego Creek Nr York Haven, PA | --- | 3 | 0.6 | 0.5 | --- | 0.7 | 0.3 | --- | --- | --- | 9 | --- | --- |
| Codorus Creek Nr Codorus Furnace, PA | --- | 11 | 3.0 | 1.1 | 2.6 | 0.8 | --- | --- | --- | --- | 20 | --- | --- |
| Susquehanna River @ Columbia, PA | --- | 12 | 4.8 | 3.0 | 2.8 | 2.7 | --- | --- | --- | --- | 30 | --- | --- |
| Susquehenna River @ Wrightsville, PA | --- | 84 | 22 | 6.5 | 63 | 5.5 | --- | --- | --- | --- | 60 | --- | --- |
| Conestoga River @ Conestoga, PA | --- | 11 | * | --- | 3.6 | 0.8 | --- | --- | --- | --- | 23 | --- | --- |
| **Susquehenna River Nr Port Deposit, MD | | | | | | | | | | | | | |

--- Indicates Compound Was Not Detected
* Sample Not Determined
** Site Not Sampled in 1974

that the 1988 samples averaged more than twice the silt and clay content found in the 1974 samples. The one notable exception -- one which was anticipated because of the reduction in use of leaded gasoline -- was a reduction in lead (Pb) content. The mean concentration in 1974 was 123 mg/kg and decreased to a mean concentration of 76 mg/kg in 1988. The mean concentration for arsenic (As) and mercury (Hg) were approximately the same, however, maximum concentrations for both were higher in 1988.

## SUMMARY

In summary, a total of 12 out of 24 sites have shown some degree of contamination, either by detection of organic compounds, very high concentrations of metals, or the presence of some toxicant as indicted by the Microtox bioassay. However, only two of these 12 contaminated sites indicated both chemical contamination as well as a toxic response from the bioassay. It, therefore, appears that there is poor correlation between detection of priority pollutants and the toxic response by the Microtox bacteria.

There also appeared to be a major decrease in the content of organochlorine insecticides and PCB's in the bed sediment within the river system from 1974 to 1988.

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# APPENDIX A

## THE 129 PRIORITY POLLUTANTS

### Volatile organic compounds (31)

acrolein
acrylonitrile
benzene
carbontetrachloride
chlorobenzene
1,1-dichloroethane
1,2-dichloroethane
1,1,1-trichloroethane
1,1,2-trichloroethane
1,1,2-2-tetrachloroethane
chloroethane
2-chloroethylvinyl ether
chloroform
1,1-dichloroethylene
1,2-trans-dichloroethylene
1,2-dichloropropane
1,3-dichloropropene
ethylbenzene
methylene chloride
methyl chloride
methyl bromide
bromoform
dichlorobromomethane
trichlorofluoromethane
dichlorobromomethane
chlorodibromomethane
tetrachloroethylene
toluene
trichloroethylene
vinyl chloride
bis (chloromethyl) ether

### Base-neutral extractable organic compounds (46)

acenaphthene
benzidine
1,2,4-trichlorobenzene
hexachlorobenzene
hexachloroethane
bis (2-chloroethyl) ether
2-chloronaphthalene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,3'-dichlorobenzidine
2,4-dinitrotoluene
2,6-dinitrotoluene
1,2-diphenylhydrazine
fluoranthene
4-chlorophenyl phenyl ether
4-bromophenyl phenyl ether
bis (2-chloroisopropyl) ether
bis (2-chloroethoxy) methane
hexachlorobutadiene
hexachlorocyclopentadiene
isophorone
naphthalene
nitrobenzene
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosodi-n-propylamine
butyl benzyl phthalate
di-n-butyl phthalate
di-n-octyl phthalate
diethyl phthalate
dimethyl phthalate
benzo(a)anthracene
benzo(a)pyrene
3,4-benzofluoranthene
benzo(k)fluoranthene
chrysene
acenaphthylene
anthracene
benzo(ghi)perylene
fluorene
phenanthrene
dibenzo(a,h)anthracene
ideno(1,2,3-cd)pyrene
pyrene
bis (2-ethylhexyl) phthalate

### Acid extractable organic compounds (11)

2,4,6-trichlorophenol
parachlorometa cresol
2-chlorophenol
2-nitrophenol
pentachlorophenol
2,4-dimethyphenol
4-nitrophenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
2,4-dichlorophenol
phenol

### Pesticides and PCB's (26)

aldrin
dieldrin
chlordane
4,4'-DDT
4,4'-DDE
4,4'-DDD
a-endosulfan
b-endosulfan
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
a-BHC
b-BHC
q-BHC
w-BHC
PCB-1242
PCB-1254
PCB-1221
PCB-1232
PCB-1248
PCB-1260
PCB-1016
toxaphene
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

### Metals (13)

antimony
arsenic
beryllium
cadmium
chromium
copper
lead
mercury
nickel
selenium
silver
thallium
zinc

### Miscellaneous (2)

asbestos
total cyanides


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